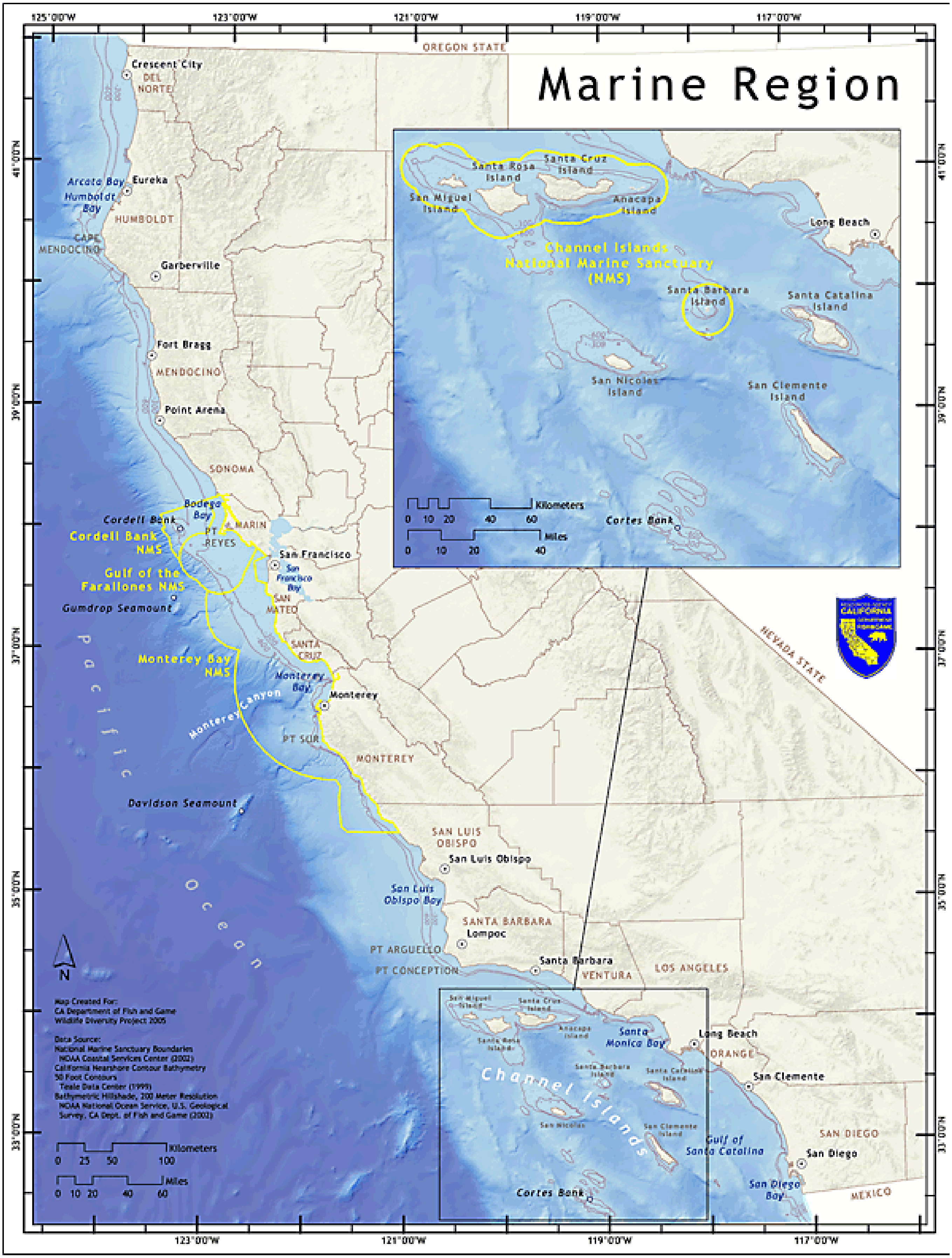
15 Marine Region

1. Overview

Along the western edge of California lies a stretch of wilderness that ranks as one of our planet's most productive ecosystems, with a plant and animal mass far exceeding that of the world's tropical rainforests. Comprising mountains, canyons, and forests, it supports some of the most diverse assemblages of wildlife found anywhere in the world. California's economy is in large part driven by it, the livelihoods of many Californians depend upon it, and one could argue that this particular region is what makes California an ultimate destination for people from all over the world.

This wilderness is the Pacific Ocean, its waves breaking along 1,100 miles of California's coastline. The Pacific's California Current, which flows down the North American Pacific Coast from Alaska to Central America, drives one of the most biologically important ocean upwelling systems in the world, where cold water, rich with nutrients, rises up from the depths of the ocean to the surface just off the coast. These nutrient-rich waters flow over, under, through, and past a diversity of coastal and underwater habitats, supporting abundant marine wildlife both in and above the water. Eelgrass beds, kelp forests, subtidal reefs, seamounts, canyons, vast expanses of featureless muddy or sandy bottom, and the **pelagic** zone create a complexity of habitats that maintains a dazzling level of biodiversity under water. Above the high-tide line, sandy beaches, headlands, estuaries, rocky shorelines, intertidal zones, offshore rocks, and islands provide critical habitat for marine birds and mammals and are what make the California coast spectacular. California's marine region is home to millions of mammals, birds, fish, sharks, turtles, urchins, clams, crabs, and worms; to grasses, algae, and other plants; and to trillions of


Marine Region
OREGON STATE
NEVADA STATE
MEXICO
Crescent City
DEL NORTE
Arcata Bay
Eureka
Humboldt Bay
HUMBOLDT
CAPE MENDOCINO
Garberville
Fort Bragg
MENDOCINO
Point Arena
SONOMA
Bodega Bay
Cordell Bank
Cordell Bank NMS
PT REYES
MARIN
San Francisco
San Francisco Bay
Gulf of the Farallones NMS
SAN MATEO
Gumdrop Seamount
SANTA CRUZ
Monterey Bay NMS
Monterey Bay
Monterey
Monterey Canyon
PT SUR
MONTEREY
Pacific
Davidson Seamount
Ocean
SAN LUIS OBISPO
San Luis Obispo
San Luis Obispo Bay
SANTA BARBARA
Lompoc
PT ARGUELLO
PT CONCEPTION
Santa Barbara
VENTURA
LOS ANGELES
Santa Monica Bay
Long Beach
ORANGE
San Clemente
Channel Islands
Gulf of Santa Catalina
SAN DIEGO
San Diego
San Diego Bay
Cortes Bank
Santa Rosa Island
Santa Cruz Island
San Miguel Island
Anacapa Island
Channel Islands National Marine Sanctuary (NMS)
Santa Barbara Island
Santa Catalina Island
San Nicolas Island
San Clemente Island
Kilometers
0 10 20 40 60
Miles
0 10 20 40
125°00'W
123°00'W
121°00'W
119°00'W
117°00'W
41°00'N
39°00'N
37°00'N
35°00'N
33°00'N
N
Map Created For:
CA Department of Fish and Game
Wildlife Diversity Project 2005
Data Source:
National Marine Sanctuary Boundaries
NOAA Coastal Services Center (2002)
California Nearshore Contour Bathymetry
50 Foot Contours
Teale Data Center (1999)
Bathymetric Hillshade, 200 Meter Resolution
NOAA National Ocean Service, U.S. Geological Survey, CA Dept. of Fish and Game (2002)
Kilometers
0 25 50 100
Miles
0 10 20 40 60

microscopic plants and animals that float in the water, contributing to the planet's carbon- and oxygen cycles and feeding millions of other ocean organisms.

At the same time, the 220,000 square miles of combined state and federal waters off the coast of California support some of the busiest shipping lanes and ports in the world, multimillion-dollar commercial and recreational fisheries and tourism industries, and unparalleled opportunities for wildlife viewing and recreation. The coast's ecological and economic amenities offer compelling reasons to want to live in California. Indeed, 80 percent of the state's 36.8 million residents live within 30 miles of the coastline; not surprisingly, this isn't without its ramifications for the health and integrity of California's marine region and the wildlife it supports. Under pressure are the largest concentrations of breeding seabirds in the lower 48 states, the most diverse assemblage of marine mammals anywhere in the world, and the critical feeding and breeding grounds of dozens of threatened and endangered species, including the southern sea otter, the Northern elephant seal, the leatherback sea turtle, the white abalone, the Western snowy plover, and many others.

The pressures on wildlife resources that exist at the interface between urban development and oceans are similar the world over. Resource extraction, loss of habitat, pollution, invasive species, and global climate change threaten marine species off the coast of California just as they threaten marine wildlife in other parts of the Pacific and the world. That said, issues of wildlife management and conservation in California's marine region are unique in a few key respects. Because California's marine region is of global importance as an area of intense productivity and biodiversity, what happens here has ramifications for marine wildlife living throughout the Pacific Ocean, and the ever-increasing population of California confers a rising level of pressure on this system and the wildlife that depend upon it.

California Marine Policy

Conservation of marine biodiversity will require both a significant advancement in our understanding of marine ecosystems and the development and implementation of new and innovative tools for managing and conserving habitats and the marine life they support. Two reports on the status of oceans and ocean management in the United States, one produced by the Pew Oceans Commission, the other by the United States Commission on Ocean Policy, were released in spring 2003. These two independent and nearly simultaneous publications essentially came to the same conclusion: The nation's oceans are in trouble, and radical changes are essential in the way federal and state governments manage them.

Upon the release of these reports, California was already at the forefront in recognizing that the conservation of marine life diversity and abundance largely depends on the development and implementation of new marine policy. The Marine Life Management Act (MLMA), effective January 1999, marked a new era in fisheries management in California. The MLMA focuses on managing for long-term sustainability over short-term economic gain, acknowledges that marine resources have nonconsumptive value to the public as a whole, and recognizes that healthy and intact marine habitats are essential for sustaining life in the ocean. It represents a radical departure from previous approaches to marine management, in that it calls for a science-based, multispecies, ecosystem-level approach to managing living marine resources.

Under the MLMA, the California Department of Fish and Game is charged with developing fishery management plans (FMPs), which are the primary basis for management. They are to be based on the best available science, fairly allocate increases or restrictions on harvest between commercial and recreational sectors, and involve stakeholders and constituents in the management planning process. Pursuant to the MLMA, Fish and Game developed FMPs for the white seabass, nearshore finfish, and market squid fisheries. The nearshore finfish plan exemplifies the application of an ecosystem-based approach: it focuses on 19 species (including several rockfish and greenling species, California sheephead, and cabezon) and makes recommendations for sustainably managing these populations through seasonal and area closures; restricted access to the fishery; regionally specific management to address variability in distribution and abundance of these species; and precautionary approaches to both the commercial and recreational fisheries. The nearshore finfish FMP also calls for research to generate data that will enable managers to adaptively manage the fishery as knowledge improves.

California's Marine Life Protection Act, effective in 1999, also set the precedent for new marine policy. In the early 20th century, about the time that President Theodore Roosevelt was establishing the country's national park system to protect vast stretches of wild lands, a fisheries biologist from Southern California noted that fish populations around Santa Catalina Island had declined dramatically due to "… lack of protection and overfishing" (McArdle 2002). Nearly a century later, with just 0.006 percent of state and federal waters off California's coast designated as areas completely off-limits to fishing, the state of California passed the Marine Life Protection Act (MLPA). Establishing marine protected areas that limit human extraction of resources and alteration of habitats allows populations of fish and invertebrates to remain viable through the vagaries of environmental variation and oscillation. California's MLPA mandates a process for the establishment of a network of marine protected areas (MPAs) to help conserve the diversity and abundance of marine life and the integrity of marine ecosystems in California and requires that those areas be designed and sited according to sound science. (See Fig. 15.1.)

Most recently, in 2004, California heeded the call to action as laid out in the Pew Oceans Commission's and the U.S. Commission on Ocean Policy's reports by enacting the California Ocean Policy Act, which aims to better coordinate marine resource management across agencies by establishing the California Ocean Protection Council. Chief among this council's mandates is identifying a steady and sustainable source of revenue to support marine management and conservation in the state.

At the federal level, the Magnuson-Stevens Fishery Conservation and Management Act (1976, amended in 1996) guides the management of fisheries in federal waters, from 3 to 200 nautical miles offshore, via eight management councils around the country that address regionally specific issues

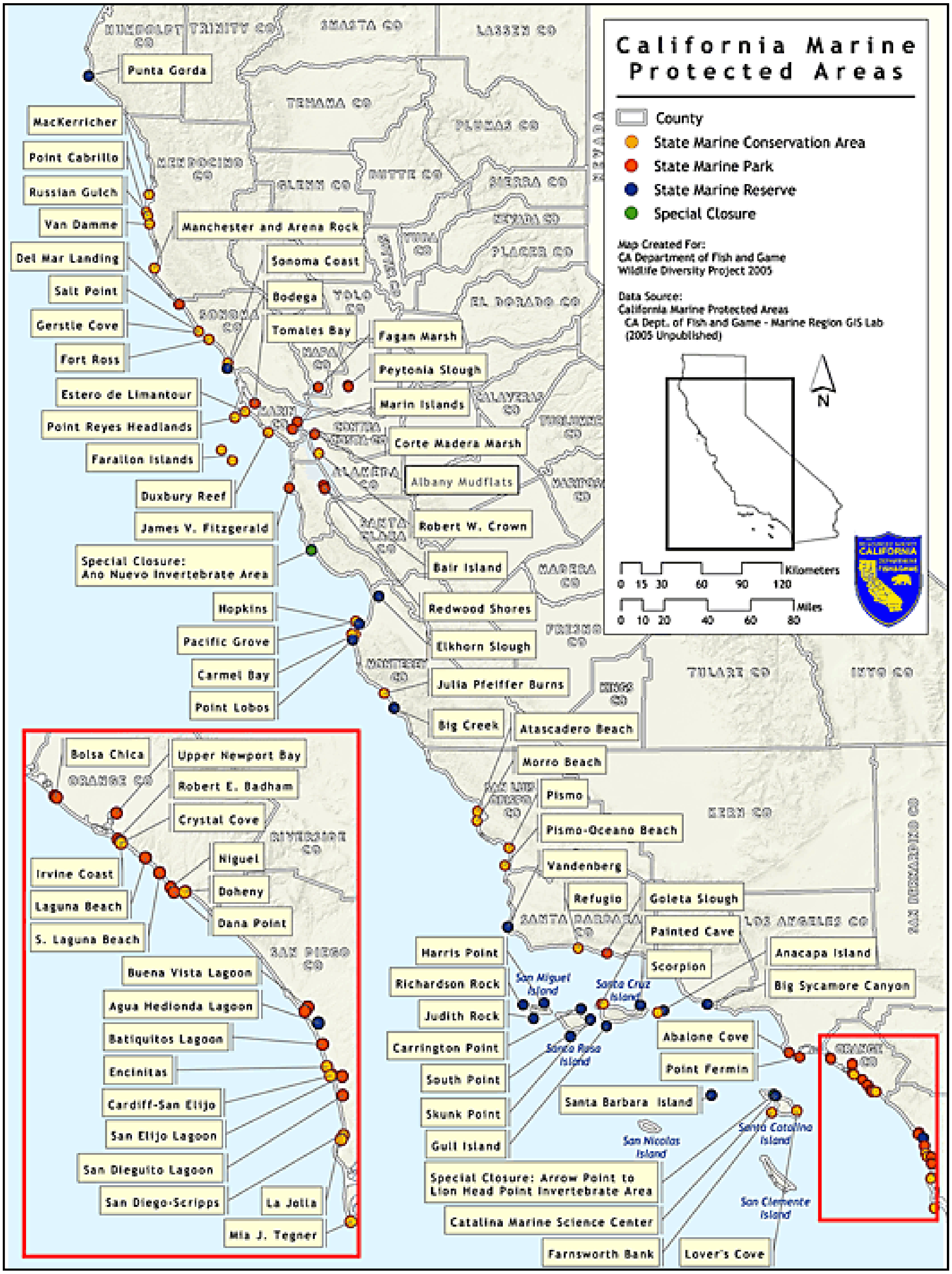


Fig. 15.1: Marine Protected Areas

pertaining to the sustainability of federally managed fisheries. The Pacific Fishery Management Council advises the National Marine Fisheries Service on the management of fisheries for salmon, groundfish (e.g., rockfish, lingcod, cabezon, Pacific cod, sole, flounder), sharks and skates, highly migratory species (e.g., tuna, billfish, dorado) and coastal pelagics (e.g., sardines and mackerel) off the coasts of California, Oregon, Washington, and Alaska. The council regulates these fisheries by implementing management plans calling for periodic stock assessments and controlling harvest of these species through seasonal and area closures, reductions in allowable **take**, and in the number of permits allowed for each fishery. Fish and Game works with the council and the National Marine Fisheries Service to manage those fisheries guided by a federal FMP for species caught or landed in California waters (e.g., rockfish, salmon, and sharks).

2. Species at risk

The Plan development team updated vertebrate and invertebrate species information in the California Natural Diversity Database (CNDDB) during 2004–2005. The following regional summary of numbers of wildlife species, **endemic** species, and **species at risk** is derived from the updated CNDDB.

There are 638 vertebrate species that inhabit the Marine Region at some point in their life cycle, including 163 birds, 62 mammals, 15 reptiles, four amphibians, and 394 fish. Of the total vertebrate species that inhabit this region, 38 bird **taxa**, 17 mammalian taxa, four reptilian taxa, two amphibian taxa, and 26 fish taxa are included on the **Special Animals List**. Of these, 15 are endemic to the Marine Region, and one species found here is endemic to California but not restricted to this region (Table 15.1).

Table 15.1: Endemic Special Status Vertebrates of the Marine Region

*	*Amphispiza belli clementeae*	San Clemente sage sparrow
*	*Aphelocoma insularis*	Island scrub-jay
*	*Batrachoseps pacificus pacificus*	Channel Islands slender salamander
	Eucyclogobius newberryi	Tidewater goby
*	*Lanius ludovicianus anthonyi*	Island loggerhead shrike
*	*Lanius ludovicianus mearnsi*	San Clemente loggerhead shrike
*	*Peromyscus maniculatus anacapae*	Anacapa Island deer mouse
*	*Peromyscus maniculatus clementis*	San Clemente deer mouse
*	*Pipilo maculatus (=erythrophthalmus) clementae*	San Clemente (spotted) towhee
*	*Pituophis catenifer pumilis*	Santa Cruz Island gopher snake

*	*Reithrodontomys megalotis santacruzae*	Santa Cruz harvest mouse
*	*Sorex ornatus willetti*	Santa Catalina shrew
*	*Spilogale gracilis amphiala*	Channel Islands spotted skunk
*	*Thamnophis hammondii ssp*	Santa Catalina garter snake
*	*Urocyon littoralis*	Island fox
*	*Xantusia riversiana*	Island night lizard
* denotes taxon is endemic to region		

Marine invertebrate diversity is poorly known, but we do know that marine invertebrate species far outnumber vertebrate species in the ocean. In the Marine Region, 19 invertebrate taxa are included on the Special Animals List, including five arthropod taxa and 14 mollusk taxa. Of these, 17 are endemic to the Marine Region, and one other taxon found here is endemic to California but not restricted to this region (Table 15.2).

Table 15.2: Endemic Special Status Invertebrates of the Marine Region

*	*Ashmeadiella chumashae*	A megachilid bee
*	*Binneya notabilis*	Santa Barbara shelled slug (=slug snail)
	Cicindela hirticollis gravida	Sandy beach tiger beetle
*	*Coenonycha clementia*	San Clemente coenonycha beetle
*	*Haplotrema catalinense*	Santa Catalina lancetooth
*	*Haplotrema duranti*	Durant's snail
*	*Helminthoglypta ayresiana sanctaecrucis*	Ayer's snail
*	*Lasioglossum channelense*	Channel Island halictid bee
*	*Micrarionta facta*	Santa Barbara islandsnail
*	*Micrarionta feralis*	San Nicolas islandsnail
*	*Micrarionta gabbi*	San Clemente islandsnail
*	*Micrarionta opuntia*	Pricklypear islandsnail
*	*Pristiloma shepardae*	Shepard's snail
*	*Radiocentrum avalonense*	Catalina mountainsnail
*	*Sterkia clementina*	San Clemente Island blunt-top snail
*	*Trigonoscuta stantoni*	Santa Cruz Island shore weevil
*	*Xerarionta intercisa*	Horseshoe snail
*	*Xerarionta redimita*	Wreathed island snail
* denotes taxon is endemic to region		

The Wildlife Species Matrix, including data on listing status, habitat association, and population trend for each vertebrate and invertebrate species included on the Special Animals List, is available on the Web at http://www.dfg.ca.gov/habitats/wdp/matrix_search.asp. For vertebrates, the matrix also includes links to species-level range maps. Additionally, a link to the California Department of Fish and Game's online Field Survey Form is available to assist in reporting positive sightings of species on the Special Animals List to the California Natural Diversity Database (CNDDB).

Two Species at Risk

Note: *The following discussion of two species at risk illustrates how stressors or threats affect species and highlights conservation challenges and opportunities. These species discussions are not intended to imply that conservation should have a single-species approach.*

The plight of each of these species is an example of the myriad challenges facing marine wildlife in California. The histories of abalone and common murre populations in California are quintessential stories of how stressors affect marine wildlife and diversity.

Abalone

Prized for their meat and their brilliant shells, abalone have been harvested in California for as long as humans have lived here. Native Americans and European settlers gathered them from beaches and intertidal zones, while southern sea otters preyed upon them in deeper water. Despite human and otter predation, abalone populations were able to sustain themselves because large adults, capable of producing millions of larvae, hid in inaccessible crevices, out of reach of predators. There were enough of these reproductive adults, and they were close enough together, that each year when they spawned millions of eggs and sperm into the water, enough embryos would develop into planktonic larvae that, during years when the oceanographic conditions were right for **recruitment**, the larvae managed to settle onto appropriate habitat, where they developed into juveniles and then adult animals.

When, as a result of the fur trade, southern sea otters all but disappeared in the 19th century, abalone populations flourished. The "abnormal" abundance of abalone in the 20th century drove a lucrative commercial and recreational fishery for several of the abalone species living along the coastline. In Southern California, fishermen first focused their efforts on red abalone and pink abalone, then greens, then whites, and finally they harvested black abalone. This serial depletion of abalone species helped drive a near-total collapse of abalone populations in Southern California (Karpov et al. 2000). In 1997, a moratorium was placed on all abalone fishing south of San Francisco Bay; today, only red abalone may be taken, only by recreational fishermen without the aid of scuba gear, and only north of San Francisco. Red abalone populations in Northern California appear to be stable (although there is some concern about recruitment), in part because the Fish and Game Commission has placed more stringent controls on how many abalone may be harvested each year by licensed recreational fishermen and also because free divers simply cannot descend far enough to collect the ones that live at depth (Karpov et al. 1998). The red abalone population in Southern California, on the other hand, is still at critically low densities.

Theoretically, the ban on all fishing for abalone south of San Francisco should have resulted in the steady improvement of abalone numbers, but their populations continued to decline after the fishery was closed. This is in part due to disease; black abalone, in particular, were hard-hit beginning in the mid-1980s by a disease called withering syndrome, and this emerging disease resulted in dramatic declines in this species both in the Channel Islands and on the mainland. But the inability of abalone populations to recover on their own in the absence of fishing pressure may also be due to the "Allee effect": Remaining breeding-age adults are now simply too few and far between to successfully reproduce. When they broadcast spawn, they are so far apart that their sperm and eggs do not mingle in the water column. The result is too few larvae and juveniles drifting in the pelagic zone, ready to take advantage of prime ecological conditions for development into adults. Most abalone populations have simply become so small that many scientists and resource managers believe they will never recover to the point of again sustaining a fishery. In May 2001, the National Marine Fisheries Service listed the white abalone as an endangered species under the Endangered Species Act, making it the first marine invertebrate whose listing was largely due to human take.

Common murre

The common murre is a striking black-and-white bird that nests on offshore rocks and islands from British Columbia to Baja California. It feeds by ducking below the surface and "flying" underwater to catch fish and invertebrates and has been recorded as diving to depths exceeding 500 feet in pursuit of prey. When common murre chicks are just a few weeks old and still small, weighing only 25 percent of their adult body weight, they head out onto the water with one of their parents (usually the male), where they are attended and fed by that parent until well after they learn how to fly. In mid-to-late summer off California's coast, these adult-chick pairs, along with nonbreeding juveniles and adults, form vast rafts of birds sitting on the water.

The common murre is the most abundant breeding seabird off the coast of California, and, overall, their populations in the North Pacific are relatively stable. However, because these are ground-nesting, surface-dwelling birds that dive underwater to feed, they are uniquely sensitive to certain types of human activities. As a result, historically they have suffered huge declines in California at the hands of humans. In the early 1800s, there were likely close to 3 million birds nesting on the Farallon Islands in Central California (Manuwal et al. 2001). However, hunting and egg collecting by European settlers in the early 19th century had devastating and cumulative effects, and, by 1930, the colony was pushed to near-extinction. Over this same period, the southernmost colonies of common murres in the Channel Islands also disappeared.

Fortunately, the disallowing of egg collecting and increased levels of government protection for nesting habitat allowed common murres to begin rebounding. But between 1979 and 1989, the Central California common murre population plummeted once again, declining by almost 10 percent a year; by 1989, the total state population was half of what it was in 1980 (Manuwal et al. 2001). This decline was in part due to the 1982–1983 El Niño season, when many young birds starved due to the collapse of their prey base. But the population's ability to recover from this natural climatic event was severely hampered by oil pollution and gill net fisheries. More than 75,000 common murres died between 1979 and 1987 as a result of entanglement in gill nets in Monterey Bay, the Gulf of the Farallones, and Bodega Bay (Mills and Sydeman 2004). During this same period, two major oil spills occurred, each of which killed several thousand murres.

While common murre populations are increasing once again in Central California, in part due to bans placed on gillnetting in the 1980s and 1990s, they still have not recolonized the Channel Islands, and they remain susceptible to entanglement in other types of fishing gear and to oil statewide. Indeed, common murres continue to be the most susceptible of seabirds species in California to the consequences of oil contamination of the marine environment; just recently, oil leaking from the *Jakob Luckenbach*, which sank in 1954 in the Gulf of the Farallones, killed an estimated 20,000 seabirds throughout the winter of 2003, most of them common murres (Hampton et al. 2003a).

3. Stressors Affecting Marine Wildlife and Habitats

The diversity and abundance of marine wildlife in California are profoundly affected by human activities in, on, and alongside the water, and the focus of this report is on those stressors and how to address them.

It is important, however, to consider marine stressors in the context of the natural variation that occurs as a result of large-scale shifts in oceanographic conditions, which create a background of natural change that has a profound impact on marine diversity. For example, the distribution and abundance of marine species very much depend on the strength and temperature of the California Current, which itself varies on a scale measured in decades. When atmospheric pressure in the far northern Pacific is high, the California Current is stronger, the water temperature is colder, and significant upwelling drives high productivity of the ecosystem, allowing populations of many species to flourish under these conditions of plentiful food. When atmospheric pressure in the far northern Pacific is lower, the California Current weakens, water temperatures rise, and there is less upwelling of nutrient-laden water. As a result, the planktonic biomass shrinks, as do the size and range of populations of marine wildlife positioned higher in the food web.

Another oceanographic process that affects the distribution and abundance of marine species is the El Niño–Southern Oscillation (ENSO), when the temperature of the equatorial ocean off the coast of South America rises. When ENSOs are particularly strong, warming of ocean water extends further north of the equator than usual, affecting the California Current. Warmer ocean temperatures off our coast favor the presence of more of the species that prefer warmer water and are less hospitable for the coldwater species, which then typically move offshore. The opposite occurs the year after a strong

ENSO, when the waters off our coast become cooler than usual. Strong El Niño–Southern Oscillation events appear to be increasing in frequency, possibly due to global climate change.

These regime shifts in oceanographic conditions mean that, over billions of years, marine organisms have evolved life-history strategies—growth processes, feeding preferences, movement patterns, reproductive behaviors—that enable populations of species to survive periods of low food availability or years when ocean temperatures or ocean current characteristics do not favor the successful production of next year's generation of organisms. The distribution and abundance of marine species naturally fluctuate over time with shifts and changes in the ocean, and populations and ecosystems remain intact because they are large and resilient enough to make it through the tough years.

The challenge for many marine species now, however, is that humans have disrupted the intricacies of this dynamic system such that human activities in and on the ocean cause additional stress for marine species in California. Major stressors affecting marine wildlife and their habitats in California are:

- Overfishing
- Degradation of marine habitats
- Invasive species
- Pollution
- Human disturbance

Overfishing

Commercial and recreational fishing is an important stressor affecting marine wildlife diversity in California. While fishing is of significant socioeconomic value in the state's coastal communities, every year it results in the removal of large numbers of fish from the ocean. Fishing directly reduces the abundance of fish and may indirectly affect the abundance and diversity of other species, including birds and mammals, that share the marine ecosystem with fish.

The direct effect of fishing is a matter of numbers; millions of fish are harvested every year. In 2003, 274 million pounds of fish were commercially landed in California (CDFG 2004d). Between 1998 and 1999, recreational fishermen caught 17.8 million fish, of which 9.6 million were harvested whole, 7.1 million were returned live to the water, and 1.2 million were used as bait, filleted at sea, or discarded dead (Leet et al. 2001). The Southern California commercial-passenger fishing-vessel fleet alone caught an average of 4.25 million fish a year between 1963 and 1991; notably, despite a consistent fleet size of approximately 200 boats since 1991, this figure has decreased to 2.5 million fish a year (Dotson and Charter 2003).

The level of harvest that occurred in the last century in California—indeed, throughout the world (Jackson et al. 2001)—was largely the result of a general sense that the ocean's bounty was limitless, an attitude shared equally by both the fishermen and the fisheries managers. Regulations placed on fisheries were often not precautionary, and commercial and recreational fishermen had the equipment and technology to catch whatever the regulators would allow.

The lack of a precautionary approach in some cases has contributed to the decline of some populations to very low numbers. As of 2003, 36 percent of United States' commercially harvested stocks (those for which we have enough information with which to assess their status) are officially categorized as overfished; another 21 percent are classified as "experiencing overfishing" (NMFS 2004). Information isn't available on the status of most stocks of fish caught in California to make a similar evaluation of their status, but for species for which stock assessments have been completed relatively recently, such as for California sheephead (Alonzo et al. 2004), stocks are lower than target levels.

In the 1990s, state and federal governments began to realize that populations of species caught off this country's coasts, including in California, were in decline. As commercial landings plummeted, California began implementing restricted-access policies in some commercial fisheries. The number of permits in the nearshore finfish fishery, for example, has been reduced from roughly 1,300 to approximately 200 over the last several years. Many of California's fisheries have undergone one, if not more, reductions in the number of permits given to fishermen in order to reduce fishing pressure on declining species.

Harvesting one species can have ripple-like effects on other organisms in the marine ecosystem and can result in the decline of nonharvested species (Dayton et al. 2002). For example, heavily fishing one species can disrupt food webs: approximately 360 million of the 425 million pounds of fish commercially harvested in California in 1999 were coastal pelagic fish, such as market squid, anchovy, mackerel and sardines (Leet et al. 2001)—principal prey species for **piscivorous** fish, as well as seabirds and marine mammals.

By the same token, fishing one species can also allow another species to flourish unnaturally, thereby disrupting delicate balances among predator and prey that have evolved over eons. Such imbalances are classically illustrated in California by sea otters, sea urchins, and kelp forests. After sea otters were hunted to the brink of extinction in the late 19th century, populations of their favored prey item, sea urchins, grew exponentially. These unnaturally large populations of urchins overgrazed kelp forests, reducing this highly biodiverse habitat and thereby indirectly disrupting the life cycles of other fish species that depend upon kelp forests for habitat. Today, careful management and conservation of a remnant population of sea otters on the Central Coast has allowed the southern sea otter to rebound—at the "cost" of a sea urchin population size that some consider not large enough to sustain an urchin fishery in this part of the coast but to the benefit of healthy, intact kelp forest habitat.

Fishing can result in significant mortality to nontargeted species through unintended harvest (or "bycatch"). California lacks adequate data with which to evaluate the ecological consequences of bycatch in our marine waters. A preliminary assessment of bycatch in the spot prawn trawl fishery in 2000 and 2001 documented a significant level of bycatch and also demonstrated that, compared to trawls, spot prawn traps significantly reduced bycatch of finfish. Entanglement in fishing gear is also a significant fishing-related cause of mortality for nontarget species, including seabirds and marine mammals. Injury or death resulting from entanglement has been identified as one of the most serious threats to seabirds in California (Mills and Sydeman 2004). In Central and Northern California, most of the set gillnet fisheries were closed between 1982 and 1987, with the last few remaining set gillnet fisheries in Central California shut down in 2002, when they were determined to be drowning large numbers of seabirds and marine mammals. The set gillnet fishery was in part responsible for a 50 percent decline in the state's population of common murres in the 1980s and the bycatch of numerous other seabird species (Manuwal et al. 2001).

Degradation of Marine Habitats

Unlike terrestrial wildlife species that tend to complete their entire lifecycles within a single or perhaps a few habitat types, the life histories of most marine wildlife species involve different parts of the ocean at different stages. Many of these essential marine habitats in California have been significantly changed, either by outright loss or by degradation of the quality of what habitat remains. Habitat loss, whether quantitative or qualitative, limits the capacity of marine species to complete critical parts or even all of their life cycle. Humans have altered marine habitats in many ways, including shoreline development (in the form of bulkheads, sea walls, jetties, and marinas), fishing (via bottom trawling and deposition of debris and derelict gear), and dredging (for navigation channels and underwater cable routes).

Giant kelp forests are a globally important, highly biodiverse habitat—sometimes called the "rainforests of the sea." Numerous species of marine invertebrates, fish, and mammals are associated with giant kelp forests, which offer a broad web of food in part derived from kelps. More importantly, the kelp-forest habitat offers nursery areas and protection from predators for many marine species. The size and shape of kelp forests are determined by season, ocean temperatures, nutrient availability in the surface waters, and grazing by marine herbivores. Some kelp forests were degraded by pollution and deposition of sediments from the land (especially in Southern California), and currently, giant kelp forests are being altered by the loss of species that live in and shape the kelp forest ecosystem.

The influence of sewage and industrial outfalls on marine wildlife has been documented since the 1970s, when coastal communities began monitoring the effects of these discharge operations, and the Clean Water Act of 1972 began requiring industrial plants and regional sanitation districts to monitor and minimize the consequences of their outfalls on the marine environment. Such monitoring has significantly reduced the inflow of particulate matter and chemicals into the ocean. Nevertheless, some chemical contaminants dumped in the marine environment persist for decades, and not all sewage outfalls in California operate at the highest levels of effluent treatment. And input of solid and liquid waste and contaminants into the ocean from uncontrolled sources like storm drains—called **non-point** source pollution—continue to pollute coastal waters. The effects of coastal power plants on marine life are also of ongoing concern to resource managers and scientists. Twenty-one power plants, from Eureka to San Diego, are permitted to either withdraw or discharge nearly 17 billion gallons of seawater per day. These cooling intakes and warm-water outfalls raise the temperature of the seawater around the plant, trap fish and eggs against intake screens, and draw small aquatic organisms like eggs and larvae into the plant. This latter effect—called "entrainment"—is believed to have the greatest harmful effect on marine resources and has led the state to require several of these plants to invest in marine enhancement projects as a mitigation measure (Richins 2005).

Bays, estuaries, and lagoons sit at the land-sea interface, functionally buffering the ocean from inflows of sediments from land. Because these waters are shallow (so sunlight penetrates easily) and relatively protected from strong wind action and currents, they are highly vegetated, supporting large underwater meadows of eelgrasses and extensive tidal salt marshes. These vegetated areas function as protective and nutrient-rich nursery grounds for large numbers of marine fish and invertebrates (Beck et al. 2003). However, of all marine habitats, bays, lagoons, and estuaries are probably the hardest hit by human activity. Shoreline development, intentional draining to make way for development, and destruction of upland watersheds have all contributed to erosion and sediment runoff, damaging these shallow underwater habitats and affecting their quality as habitat for marine organisms and plants. Deposition of sediments suffocates eelgrass beds; contaminants accumulate in sediments, creating toxic microenvironments for plant roots and for larval organisms; and dredging for navigation channels digs up plants and animals, transforms bottom contours, and suspends toxic sediments and benthic organisms. Shoreline armoring (bulkheads, seawalls, jetties) and diversion of rivers and streams flowing into the ocean disrupt the normal deposition of sand onto beaches that occurs through natural erosion and transfer of suspended sands by wave action. Declines in beach quality and quantity have negative consequences for species that depend upon sandy beach habitat for reproduction, like shorebirds, sea turtles, and California grunion.

Invasive Species

The unintended introduction of invasive species to marine habitats, both underwater and on shore, is a stressor to native marine species. These non-native invaders quickly and successfully establish residency and expand their range, adversely affecting native species by preying upon them or outcompeting them for critical habitat or food. Non-native species in the marine environment tend to be a more critical issue in bays and estuaries, where they are more likely to be introduced and to gain a foothold. Once an invasive species is established in a bay or estuary, it is generally there to stay—with few exceptions, eradication of marine invasives is exceedingly difficult.

California's coastal marine ecosystem has been invaded by hundreds of non-native species; in fact, San Francisco Bay ranks as one of the most-invaded bodies of water in the world, with an estimated 225 introduced species (SFEI 2004). Estimates are that a new species is unintentionally introduced and becomes established in San Francisco Bay every 14 weeks. Well-known non-native species invasions in

California's marine environment include the European green crab, the Chinese mitten crab, the Asian clam, the yellowfin goby, and aggressive plants and algae like *Spartina alterniflora*, *Undaria*, and *Caulerpa taxifolia* (see "*Caulerpa taxifolia* Eradication"). The yellowfin goby has become one of the most abundant species in San Francisco Bay and other bays and estuaries in California and is still increasing its range (Allen et al., in prep.). The European green crab, an underwater predator, was first detected in San Francisco Bay in 1989 and has since scurried up the Pacific coast all the way to Washington. Upon its arrival in California, the green crab reduced populations of native crabs and clams, and laboratory experiments showed that it was a voracious predator of juvenile Dungeness crabs (Grosholz et al. 2000). The population of another invader, the Asian clam, is so large that it has effectively knocked out the summer phytoplankton bloom in the northern part of San Francisco Bay, depriving hundreds of endemic marine organisms of an important food source (Grosholz 2002).

The brown alga *Undaria pinnatifida*, native to Japan, was first seen in Southern California harbors in 2000. By 2001, populations of *Undaria* had established themselves in harbors as far north as Monterey and even on the open coast of Santa Catalina Island. This alga likely first arrived in ballast water but may now be spreading via the movements of small boats, to which microscopic forms of the alga have attached. The cordgrass *Spartina alterniflora*, native to the Atlantic coast, was intentionally planted years ago in San Francisco Bay because it was thought to be an effective method for restoring the estuary. However, it has since invaded many of Northern California's tidal wetlands, rapidly engulfing tidal mudflats. Its consequences for wildlife have been well studied in San Francisco Bay, where it has devastated important foraging habitat for the millions of shorebirds that migrate through the Bay Area and depend upon open mudflats for foraging (PRBO 2004b). The presence of *Spartina alterniflora* is even implicated in the decline of the California clapper rail; the plant has altered tidal habitats to such an extent that the bird is now more vulnerable to terrestrial predators.

Above the high-tide line, California's marine wildlife are also threatened by non-native terrestrial predators. Rats and cats, especially, threaten nesting seabirds in California (Mills and Sydeman 2004). Cats have been introduced to five of the Channel Islands, where they drove the Cassin's auklet to extinction on Santa Barbara Island, and black rats significantly reduced the nesting population of Xantus's murrelets on Anacapa Island. Thanks to concerted eradication efforts, cats have been removed from most of the smaller islands, including Anacapa and Santa Barbara islands, but still remain on Santa Catalina, San Nicolas, and San Clemente islands. Black rats have been removed from Anacapa Island (K. Faulkner pers. comm.) but are still present on San Miguel, San Clemente, and Santa Catalina islands. Seabirds are threatened by non-native herbivores like feral pigs, which trample nesting burrows and significantly alter native habitat by grazing on native vegetation and causing erosion. Feral pigs have been eradicated from Santa Rosa and San Clemente islands and are being eradicated on Santa Catalina and Santa Cruz Islands (Mills and Sydeman 2004, G. Davis, pers. comm.).

Pathogens have the potential to act as invasive non-native species in California's marine wildlife. For example, a significant percentage of southern sea otters that wash ashore dead are infected with a brain

Caulerpa taxifolia Eradication

In June 2000, a patch of an aggressive non-native alga called *Caulerpa taxifolia* was discovered in a small coastal lagoon called Agua Hedionda, near Carlsbad in northern San Diego County, and shortly thereafter in Orange County's Huntington Harbor. Dubbed "killer algae," this alga was well known; accidentally introduced into the Mediterranean Sea in 1984, in 13 short years it had blanketed the sea's northern coastline, displacing numerous native marine plants and animals and disrupting commercial fisheries and coastal tourism. *Caulerpa* likely showed up in Agua Hedionda Lagoon via storm drains containing discarded water from hobbyists' saltwater aquariums. Because it is capable of living in a wide range of ocean temperatures and habitats and spreads easily if pieces of the plant are torn off by anchors or stormy weather, the *Caulerpa* invasion posed an immediate and dire threat to the nearshore marine ecosystem of Southern California, especially to native eelgrass beds, which are critical habitat for numerous marine species. Upon its discovery, federal, state, and local agencies waged a no-holds-barred effort to eradicate *Caulerpa* by sealing each patch of *Caulerpa* under a tarp and treating it with chlorine. To date, this appears to have been effective; the sites remain covered with the tarps, and, so far, no new patches of *Caulerpa* have appeared in the area. And while the experience in Carlsbad prompted the state to pass legislation in September 2001 to ban the sale and possession of nine different species of *Caulerpa*, it is still available for sale via various Web sites. Most marine resource managers agree that it is just a matter of time before *Caulerpa* invades other parts of the California coast.

parasite, *Toxoplasma gondii*, which normally infects cats. Some of the dead otters are also infected with another central nervous system parasite, *Sarcocystis neurona*, which is carried by Virginia opossums and causes a well-recognized disease in horses. The exact mode of transmission of these parasites to sea otters is being investigated but is likely related to inadequate treatment of sewage effluent in some coastal areas such as Morro Bay (Kreuder et al. 2003). Pathogen pollution is of most concern where it may potentially affect populations of threatened or endangered species, like the southern sea otter, which, after a century of population growth, has recently shown signs of decline, in part due to infectious disease. Along these same lines, a parasitic marine sabellid worm native to South Africa was accidentally introduced into California's abalone aquaculture industry, where it devastated culture stocks. Fortunately, Fish and Game successfully eradicated this parasite from culture facilities, and it never escaped into the open water, where it might have had devastating effects on abalone species, one of which is federally endangered.

Pollution

The most well-recognized and uniformly feared form of pollution in the marine environment is oil. Whether from a catastrophic spill, a natural seep, or from a non-point source like run-off from land, oil most notably affects marine birds and marine mammals. Oil pollution also exerts damaging effects on numerous other organisms, including microscopic plankton, either by the directly toxic effects of oil exposure or by sublethal, chronic effects that limit population viability or that damage critical underwater and shoreline habitats.

Oil spills can affect thousands of birds at a time. The *Apex Houston* spill off Central California in 1986 is estimated to have killed more than 10,000 birds (Mills and Sydeman 2004). The *Jakob Luckenbach* spill, which oiled birds in the Gulf of the Farallones throughout the winter of 2003, is estimated to have killed 20,000 seabirds. The *Luckenbach* had likely been leaking oil for decades since it sank in 1954 and is now believed to have been a major source of chronic oil pollution in Central California, causing numerous “mystery” spills that have occurred year after year, especially during the 1990s (Hampton et al. 2003a). Over the last 20 years, significant numbers of seabirds have been affected by 12 major oil spills off the coast of California (Hampton et al. 2003b).

Oil in the marine environment may affect only a few individuals or whole populations, depending upon its location and whether it is present in a place or season when significant numbers of seabirds are in the area wintering, breeding, or molting. In California, the seabird species most frequently affected is the common murre, in part because, at certain times of the year, murres spend much of the time sitting on the water, where they are easily oiled. The size of an oil spill doesn’t necessarily correlate with the amount of damage it can do. Even small spills can have big consequences for birds if the oil contaminates an area where large numbers of seabirds are rafting or foraging.

Human Disturbance

As coastal communities grow, and tourism continues to bring millions of visitors every year to the California coast, more and more people seek opportunities to make their livelihoods or recreate, whether onshore, in, or on the water, bringing people and marine wildlife into closer and more-frequent proximity to one another. Disturbance, whether from light and noise produced by human activity or simply by the presence of humans themselves, can cause marine animals to alter their behaviors in ways that reduce their survival on an individual basis or disrupt breeding efforts of populations.

Hikers, boaters and kayakers, and low-flying aircraft can cause breeding birds to temporarily or permanently leave their nests, leaving the egg or chick vulnerable to exposure to weather or predation by other seabirds. People and their dogs walking on the beach startle and distress beach-feeding or -nesting shorebirds and seabirds, which then either abandon their feeding grounds or nests or simply stop establishing breeding colonies where they once did. The loss of undisturbed roosting sites was a cause of the decline of brown pelicans in the 1980s; Scorpion Rock, which sits near the main entry harbor for Santa Cruz Island, was historically an important roosting site for brown pelicans but is no longer used by the birds because the rock is so heavily used by kayakers (K. Faulkner pers. comm.). Both the Pacific population of the Western snowy plover and the California least tern have suffered population declines in California, in part because increasing numbers of people and their pets recreate in their nesting habitat on sandy beaches and in sand dunes.

Another disturbance having the potential to negatively affect California's marine wildlife populations are the increased levels of noise and light produced by at-sea industries, including fishing, drilling, and underwater engineering. The Southern California market squid fishery, for instance, uses light boats to catch squid. The amount of light produced by these boats, as much as 30,000 watts per boat (described by some as providing enough light to read a newspaper from a mile away) disrupts the ability of night-foraging birds like the state-listed Xantus's murrelet to navigate to and from foraging grounds and has resulted in nest abandonment and low reproductive success for brown pelicans (Mills and Sydeman 2004; K. Faulkner pers. comm.). The bright lights also render seabirds more vulnerable to predation by gulls and raptors. Fish and Game has worked with the market squid fishing fleet to modify their lighting equipment by shielding the bulbs (so that light is directed down onto the water surface) and limiting the maximum wattage and is working with other resource agencies and fishermen to educate vessel operators about keeping nighttime on-deck light levels low when anchored offshore of seabird islands.

Underwater noise from large ship engines, military activity, engineering, and oil and gas exploration may disturb marine mammals. Biologists have described aberrant behavior of whales and dolphins during the use of underwater sonar by naval vessels, and noise-related damage to sensory organs has been postulated as a contributor in several mass stranding events in other parts of the country. As a result, the federal government is currently conducting research on hearing thresholds of marine mammals in order to make recommendations on underwater noise levels that will minimize their effects on marine mammals.

4. Conservation Actions to Restore and Conserve Wildlife

a. The state should fully implement the Marine Life Management Act to ensure that marine fisheries and the marine ecosystem are managed sustainably.

- **The state should commit financial and personnel resources to developing and implenting fishery management plans**. Full implementation of the Marine Life Management Act (MLMA) will ensure that fisheries are managed more sustainably and with less impact on other species and habitat. However, a lack of adequate funding and personnel to support the process has resulted in a disconnect between the admirable principles and requirements within the Act and the reality of implementing it. A full rollout of the MLMA has been the responsibility of Fish and Game's Marine Region, but since the legislation's enactment six years ago, the financial and staff resources dedicated to implementing it, inadequate to begin with, have been further reduced by 25 percent. The MLMA Master Plan itself states that "Funding required for [fishery management plans] is a fundamental issue needing resolution." While the state has succeeded in developing plans under the

MLMA for nearshore finfish, white seabass, and market squid, it lacks sufficient funding and staff resources to develop them for other high-priority species identified in the FMP Master Plan.

- **The state should support and conduct more fish and invertebrate stock assessments.** Along with adequate funding and resources for developing science-based fishery management plans, the state at the same time needs to fully assess the size, age structure, or recruitment rates of the stocks of species of fish and invertebrates caught in state waters. Currently, too few such assessments are conducted by Fish and Game, again, in part, because the department has been inadequately funded and staffed to do so. Without adequate assessments, the ability of resource agencies to create and implement fishery management plans is hampered.
- **The state should expand monitoring of recreational fisheries.** The MLMA applies to all species caught in California, both commercially and recreationally. At present, the state lacks a complete understanding of the scale and scope of recreational fisheries on par with its understanding of commercial fisheries. This lack of information impairs the state's ability to incorporate appropriate measures for sustainability into fishery management plans. Fish and Game currently monitors the annual recreational take by surveying the commercial passenger fishing vessel fleet and private fishermen, using the California Recreational Fishing Statistical Survey (CRFSS). Fish and Game has tripled its surveying effort in the last year to obtain better estimates of recreational take of rockfish; the result has been more accurate data on species and total fish taken. The CRFSS applies to finfish only; thus, there is no information on recreational take of invertebrates. Along with expanding the CRFSS program, the state should look for ways to share with recreational fishermen the responsibility for monitoring catch. One possible method would be to establish angling management organizations for recreational fishing that would place monitoring and reporting responsibility on the local recreational fishing communities (Sutinen and Johnston 2003).
- **The state should support and conduct more scientific research and long-term monitoring to enable adaptive management of fisheries.** A core tenet of the Marine Life Management Act is that fisheries management plans must be based on the best available science. Furthermore, the Act mandates that the state adaptively manage fisheries; i.e., that fishery management plans be continually reassessed and revised based on new information. The state should commit more resources to support and conduct research that generates both fishery-dependent and non-fishery-dependent data essential to carrying out that mandate. Fish and Game has taken steps to address the current lack of personnel and financial resources by implementing the Cooperative Resource Assessment of Nearshore Ecosystems (CRANE) project with university scientists and other resource agencies. This highly collaborative program started in 2002 and is collecting habitat, biological, and oceanographic data by means of scuba diver- and remotely operated-vehicle surveys in shallow rocky reef habitats up and down the coast. This innovative program will, however, require new funds in order to continue over the long term. Given the current availability of financial and personnel resources, the state should continue to develop innovative

ways of conducting research, including programs that involve fishermen in data collection, and programs that utilize technologically advanced systems for collecting data and monitoring remotely. Fundamentally, however, the state needs to adequately fund and conduct marine research and resource monitoring and not rely solely on organizing others to do the critical work that is inherently governmental and core to the state's public responsibility for resource stewardship.

- **The state should evaluate bycatch.** Because it has the potential to affect marine biodiversity, the state needs to get a better handle on the extent of bycatch in the state-managed fisheries, on par with federal oversight of bycatch effects in federally managed fisheries. The state should collect data on the harvest of nontarget species in major fisheries and develop recommendations to address bycatch concerns through the fishery management plan process and through enforcement of regulations designed to protect nontarget species. This could be accomplished with fishery observers—individuals placed on commercial fishing vessels to independently record data on catch and bycatch and on interactions between the fishing vessel and sea turtles, sea birds, and marine mammals. Observer programs are a reliable independent source for this type of detailed data but potentially costly; other data collection methods, such as remote-monitoring technologies, should be considered.

b. The state should move forward in implementing the Marine Life Protection Act by establishing a network of marine protected areas.

- **The state should implement the Marine Life Protection Act statewide.** One of the best actions the state can take to ensure marine biodiversity is establishing a network of marine reserves. California recognized the need for such areas when it enacted the Marine Life Protection Act in 1999. Currently, the state is implementing the act through the Marine Life Protection Act Initiative, a public-private partnership that provides essential financial and personnel resources to the planning process in Central California. It is imperative that the state commit the financial and personnel resources to this planning process statewide, enabling a scientifically defensible network of marine reserves to be established for the benefit of marine life diversity.
- **The state should take a habitat approach to marine protected area (MPA) planning.** For the most part there is not enough fundamental biological and ecological data available to support sound decisions regarding MPA designation to be based on those criteria alone. A habitat approach to MPAs allows preservation of ecological linkages among species. To site MPAs that protect key habitats, the state should invest in the creation and distribution of a statewide detailed map of critical marine habitat upon which to base consideration of alternatives for protecting them. The habitat approach to MPA designation could apply to above-water species, as well. For example, some closures around sensitive seabird colonies have taken place through the establishment of the Channel Islands Marine Protected Areas network, but the state should consider additional protected areas around these colonies to preserve their foraging habitat during the nesting season.

- **The state should evaluate and consider marine bird and mammal migration and feeding areas in the coastal and pelagic zones as marine protected areas, and consideration should be given to protecting parts of the ocean not necessarily contiguous with a land mass.** Initial planning for pelagic reserves in California has begun (Pelagic Working Group 2002); the state should facilitate moving this process forward.
- **The state should develop a program to provide greater protection for intertidal habitats (tidepools).** Human recreational exploration of intertidal areas (tidepooling) may damage microscopic plants and animals that live on the rocks. Scientific studies have documented significant negative consequences for the intertidal zone from tidepooling activity in Southern California (Guang-yu Wang pers comm.), and other scientists have conjectured that full recovery from human damage to the intertidal zone could require decades of complete protection from human use. The state should assess whether intertidal habitats statewide need a higher level of protection from human use, so that this habitat remains intact and undamaged. An assessment will require both scientific studies and a socioeconomic analysis of tidepool use for recreation and education.
- **Federal and state agencies should partner to advance marine stewardship in areas of jurisdictional overlap, especially with regard to marine protected areas.** Multiple federal and state agencies, with varying mandates, have jurisdictional authority over marine waters off California. For example, the National Oceanic and Atmospheric Administration manages fisheries via the National Marine Fisheries Service's Pacific Fishery Management Council and regulates the use of vast tracts of coastal ocean via the National Marine Sanctuaries program. Additionally, the National Park Service is charged with protecting and conserving marine species on land and in the nearshore marine environment. The Bureau of Land Management manages the California Coastal Monument, composed of more than 20,000 offshore rocks. On the state level, the Dept. of Fish and Game manages and conserves marine resources within state waters; the California Coastal Commission regulates and oversees development and use of the coastal zone; the California State Coastal Conservancy promotes public access to the coastline and protection and enhancement of marine resources; State Parks operates several coastal protected areas; and the State Water Resources Control Board protects ocean water quality. To implement stronger, more well-coordinated and sustainable policies, all agencies with jurisdiction in California's coastal waters should promote and engage in multiagency partnerships where jurisdictions overlap and missions are complementary.
- **The state should enforce the protection of established marine protected areas.** Concurrent with the designation of marine protected areas in California must be a financial commitment on the part of the state to enforce their protected status. The state should dedicate resources to investigating, developing, and implementing new and economical ways of enforcing the protected status of these areas. Options may range from simply clearly marking the boundaries, both on the water and on maps, to on-the-water patrolling of protected-area boundaries to advise user groups

of their proximity to such areas and citing users who are violating rules and regulations. Marine reserves, areas off limits to fishing, will require an on-site enforcement approach. The state should also take a close look at the feasibility of developing technologically advanced ways of remotely monitoring protected areas; e.g., using satellite technology to monitor the proximity of fishing vessels to marine protected areas or to track boats. Ideally, such remote-monitoring programs would also enable the state to cite violators.

c. The state should secure Tidelands Revenues for implementation of the California Ocean Protection Act.

The California Ocean Protection Act (COPA), effective October 2004, has further advanced marine management in California by establishing a California Ocean Protection Council and allocating $10 million from the state's fiscal 2004–2005 budget to form the Ocean Protection Trust Fund, facilitating implementation of ocean and coastal research and management projects and policies. The act also authorizes the creation of an innovative Fisheries Revolving Loan Fund that would enable fishermen to implement projects aimed at improving commercial fisheries' financial and conservation performance, stabilizing coastal economies, increasing cost-sharing by industry, and freeing up state funds. The California Ocean Protection Act will make possible numerous additional programs and projects aimed at improving coastal water quality, enhancing coastal stewardship, and developing a long-term funding strategy for ocean and coastal protection and management. Having initially funded the California Ocean Protection Council with a one-time allocation in 2004–2005 to establish the Ocean Protection Trust Fund, it is imperative that the state ensure a long-term, permanent source of revenue to the Council in order to achieve these important marine conservation goals.

d. The state should increase efforts to restore coastal watersheds.

This recommended action is discussed extensively in the South Coast, Central Coast, and North Coast region sections of this plan, and the reader is directed to those sections for detail. However, this recommended action warrants mention in the Marine section, as well, because of its importance for restoring and maintaining healthy underwater habitat for marine life in California. The level of damage done to estuarine and shallow bay habitats from massive diversions of freshwater flow, along with the deluge of sediment washing down degraded and channelized rivers and streams, has had a significant negative effect on the health of key marine habitats like seagrass beds and kelp forests, which serve as nursery grounds for numerous marine species. From the Klamath River to the Tijuana River, it is imperative that the state continue to commit resources to the restoration of watersheds, so that they may once again act as natural buffers between land and sea.

e. The state should adopt a "no net loss" policy for critical marine habitat.

The state recognizes that coastal wetlands are a mere fraction of what they once were, that every last remaining acre must be protected, and that, to the extent feasible, concerted efforts should be made to restore wetlands to their historical status. The state should adopt a similar "no net loss" policy toward other critical habitats essential for sustaining marine diversity, such as kelp forests, seagrass beds, and beaches. When permanent damage to these essential habitats is unavoidable, the state should require that a similar amount of that habitat, or the enhanced quality or functionality of remaining habitat, is restored or created. When eelgrass beds are damaged by dredging or heavy boat use, the state should require the purposeful enhancement and/or permanent protection of the integrity of other beds, along the lines of the Southern California Eelgrass Mitigation Policy (NMFS 1991). Where kelp forests are damaged by underwater outflows, the state should continue to support the restoration of that kelp forest.

f. The federal and state resource agencies should expand efforts to eradicate introduced predators from all seabird colonies.

The state and federal resource agencies with authority to manage mainland areas and islands that support seabird colonies (the National Park Service, California Department of Fish and Game, California State Parks, and the U.S. military) should expand their collective efforts to completely eradicate all introduced terrestrial predators (primarily rats and cats) from the seabird colonies and roosting areas. The agencies should dedicate the personnel and financial resources necessary to make the long-term commitment required for these types of eradication efforts, which typically take years to achieve, and then require a commitment to maintain permanent vigilance against reinvasion. The resource agencies should also continue to control predators around mainland colonies of endangered species, such as beach-nesting colonies of Western snowy plovers and California least terns.

g. The state should systematically review and monitor the distribution and abundance of nonharvested marine fish and invertebrates.

Management and conservation of nonharvested marine fish and invertebrates is currently based on very little science. There are a paucity of historical and current data on distribution and abundance or on stressors to population sustainability. It is quite likely that many marine species native to California marine waters remain relatively or wholly undescribed by science. The state should conduct an in-depth, systematic review of the distribution and abundance of nonharvested marine fish and invertebrates within state waters, collating and collecting essential data on their distribution and abundance and on their reproductive strategies and prey preferences. The state should then assemble this data into an overall assessment of marine biodiversity and habitat in California. Where these species may be directly or indirectly affected by fisheries or habitat use, such data can then inform management and conservation plans that aim to minimize ecosystem-level effects of human activities. These data also can serve as a guide for resource agencies and the nonprofit sector in allocating their time, energy, and funding towards marine life conservation.

h. Federal and state resource agencies and institutions should foster and facilitate interstate collaborative research on marine species whose ranges cross jurisdictional boundaries.

Numerous marine species—including mammals, birds, turtles, and highly migratory fish species like tuna—range vast distances to and from breeding and feeding grounds. In some cases, species like the western sandpiper or the gray whale migrate from wintering grounds in Central America through or past California to feeding grounds in the Arctic. Improving strategies for the management and conservation of these species in California will depend upon a concerted effort on the part of all West Coast states, provinces, and countries to seek and engage in collaborative, cross-jurisdictional research and management. Whenever appropriate, the state should foster and facilitate interstate and international projects and initiatives. For some species, normal ranges can be so wide—in some instances, the entire North American Pacific coast—that, by necessity, a transjurisdictional collaborative approach will be needed to gain meaningful distribution and abundance data on which to base management decisions. Species like the gray whale and the black oystercatcher are good examples of broadly distributed species that warrant multistate collaborative research and cooperative management.